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Title: Measuring x-ray spectra with a Compton electron spectrometer

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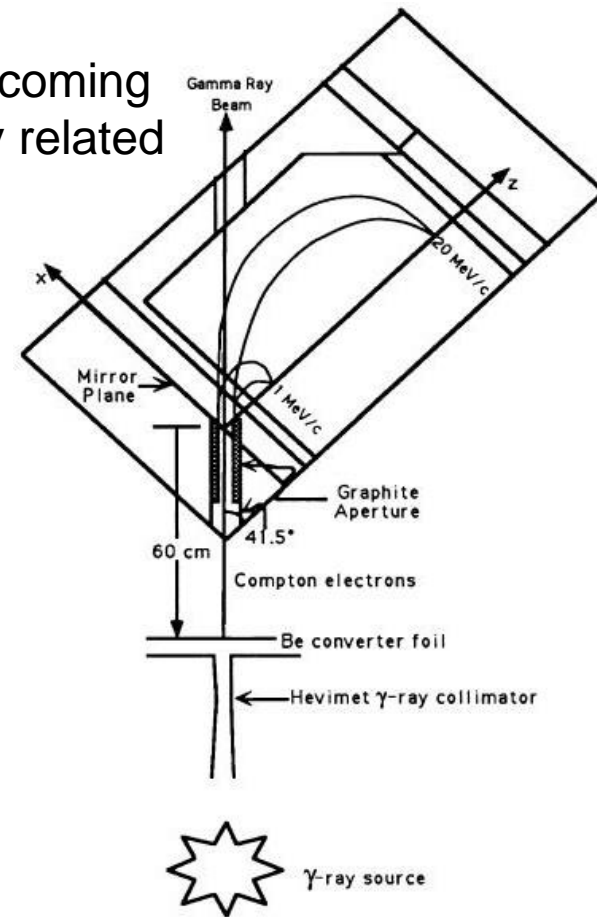
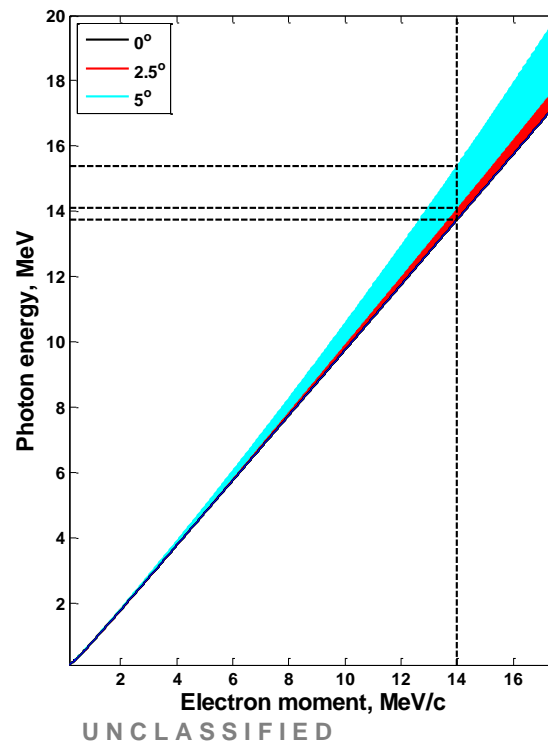
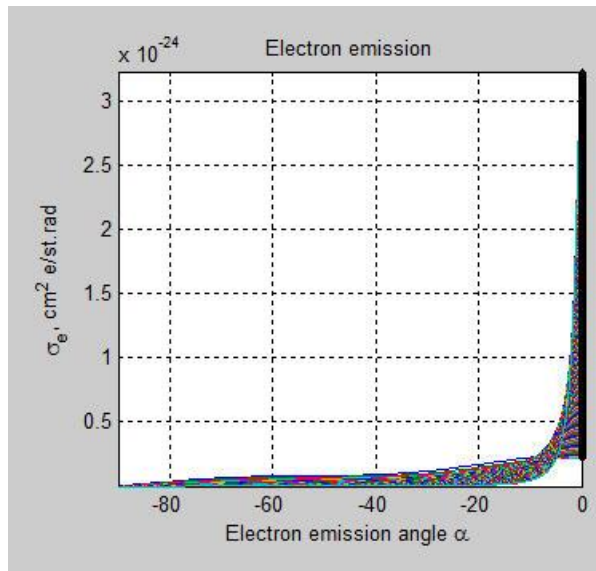
# Measuring x-ray spectra with a Compton electron spectrometer

**Michelle Espy, Mandie Gehring**

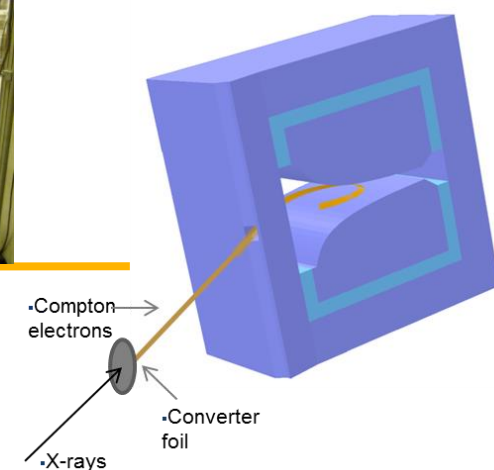
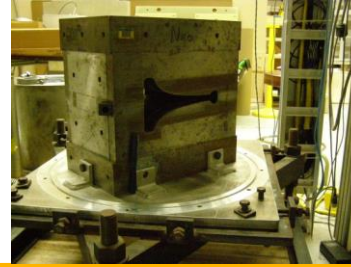


# X-rays Compton scatter into easier-to-detect electrons

- Most electrons are forward
- Restricting angular acceptance of Compton electrons, incoming gamma energies & ejected electron momenta are simply related
- Magnet relates energy to position



# Our Compton spectrometer



## ■ Demonstrated in various incarnations at NTS

- Morgan et al., NIM in Physics Research A308 (1991) 544-556
- Sale & Kammeraad SPIE Vol. 1734 Gamma-Ray Detectors (1992) p 279

## ■ Interesting features

- Distance electron crosses focal plane proportional to square root of electron momentum.
- Design achieves broad range of energies (from  $\sim 1$  MeV/c up to 30 MeV/c)
- Reported electron momentum resolution is the larger of 0.1 MeV/c or 1% of momentum

Position vs. photon energy

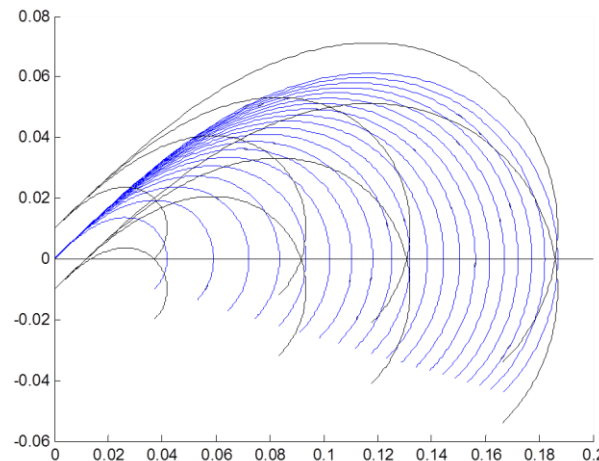
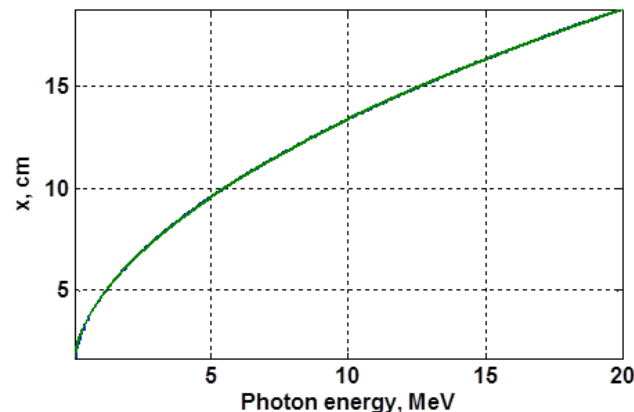


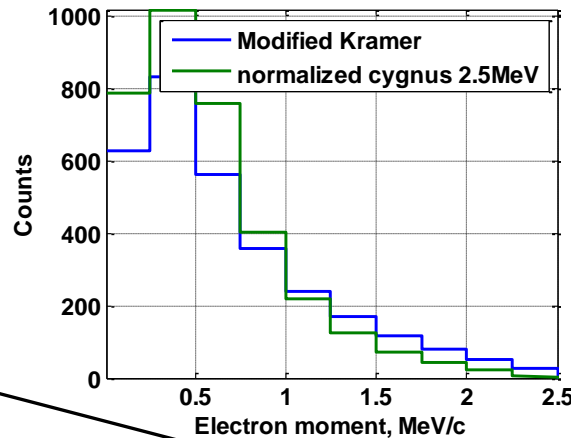
Table 1

Summary of parameters for the two models

	Sm-Co	Nd-Fe
Size [cm]	32 × 48 × 50	24 × 38 × 40
Weight [kg]	600	300
Energy range [MeV]	0.5 to 27	0.5 to 23
Focal plane [cm]	4 to 29	3 to 20
Field gradient [kG/cm]	0.35	0.65
Maximum field [kG]	10	12.5
Momentum resolution	< 1% or 100 keV/c	< 1% or 100 keV/c
Time resolution [ps]	200	200

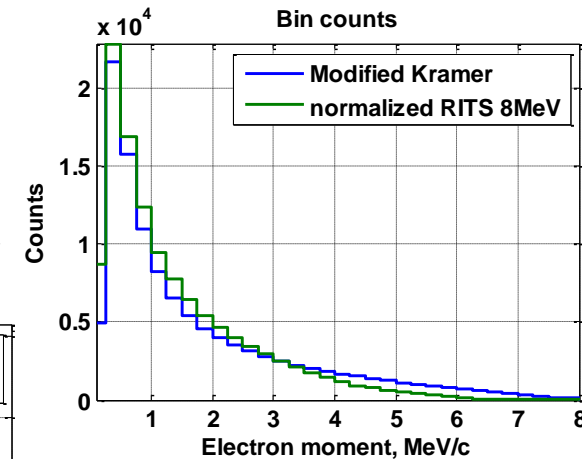
# Present spectrometer appears useful for a variety of places

- Cygnus →
- RITS →
- DAHRT →
- Other places? →

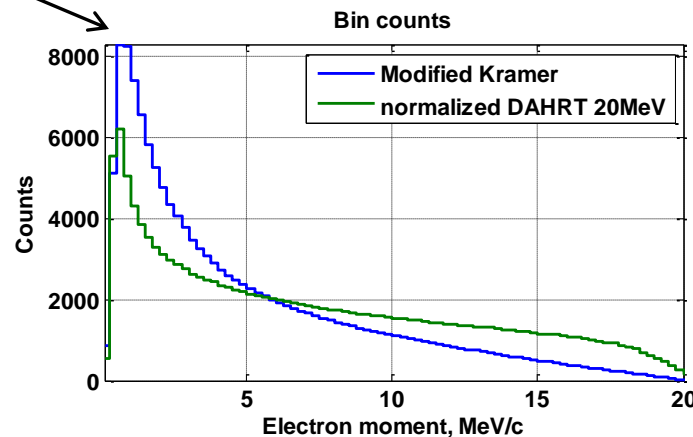


4R @ 1m

370R @ 1m



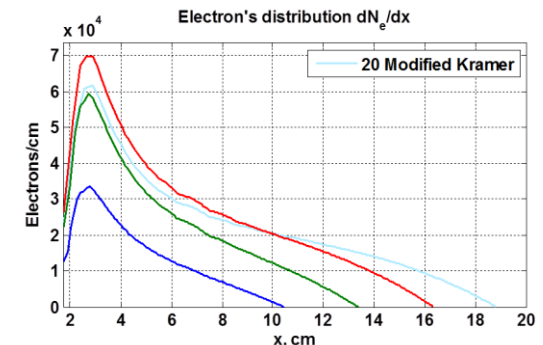
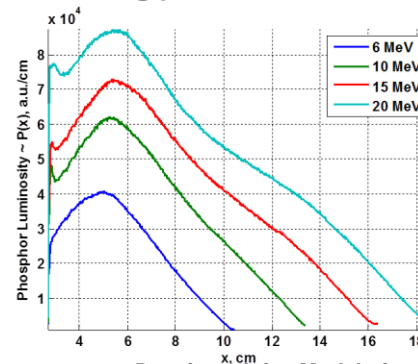
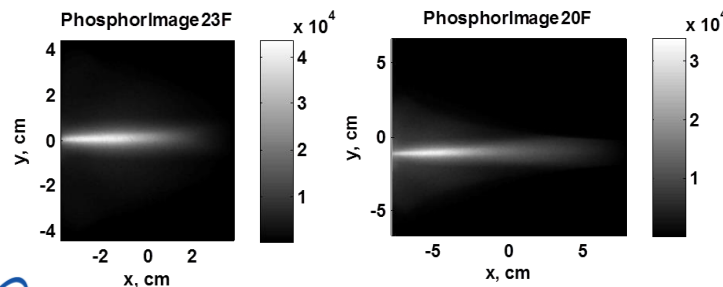
550R @ 1m



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# Recent measurements at the “microtron”

- Bremsstrahlung X-ray source with endpoint energies 6, 10, 15, 20 MeV
- Tungsten collimation to  $\sim 5$  mm
- Sweeper magnet
- Phosphor detection
  - Drop vacuum every energy change
- Unable to use graphite
  - $\sim 5^\circ$  angular acceptance
- Excellent agreement w/ predicted energy endpoints



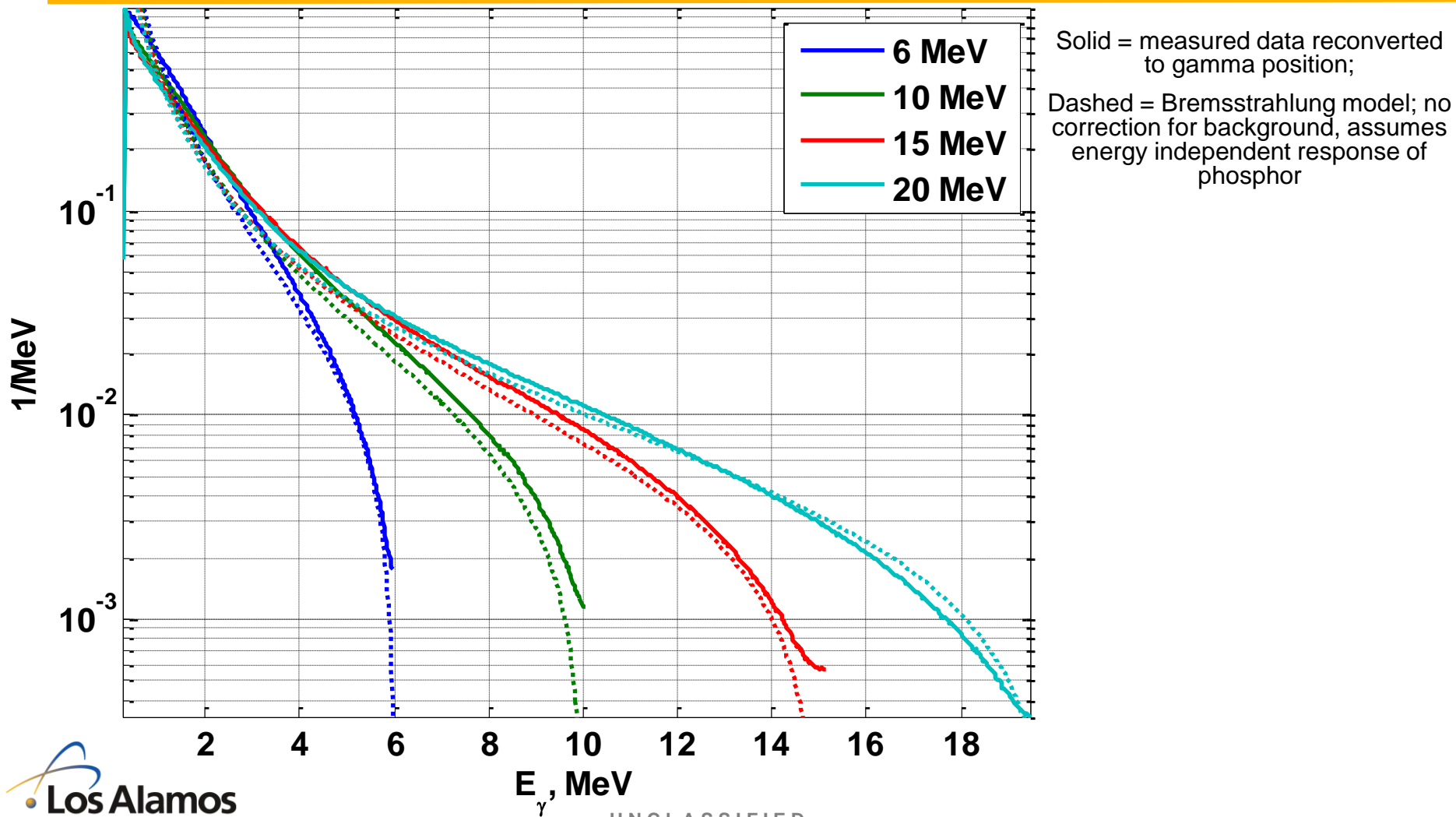
Data is on left – Model of expected electrons/cm vs position is on right

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Slide 5



## Turn back into gamma spectra



## Summary of Results so far

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- Electron endpoint energy in excellent agreement with our model
- Reconstructed spectra looks Bremsstrahlung-like (as we might expect)
- We plan to return next week to improve alignment and refine measurements

## Work in progress

- Plans to calibrate with known energies
- Develop better collimation and shielding system
- Design of a better detector system



# Energy Calibration

- $^{60}\text{Co}$  source at NSTec Source Range – resolve 1.17 and 1.33 MeV lines?
- Will need to shield spectrometer for the first time
- 20 MeV High Repetition-Rate LINAC at Idaho Accelerator Center
- Will potentially measure 0.5-20 MeV electrons, 0.5 MeV step
- Focus on alignment issues

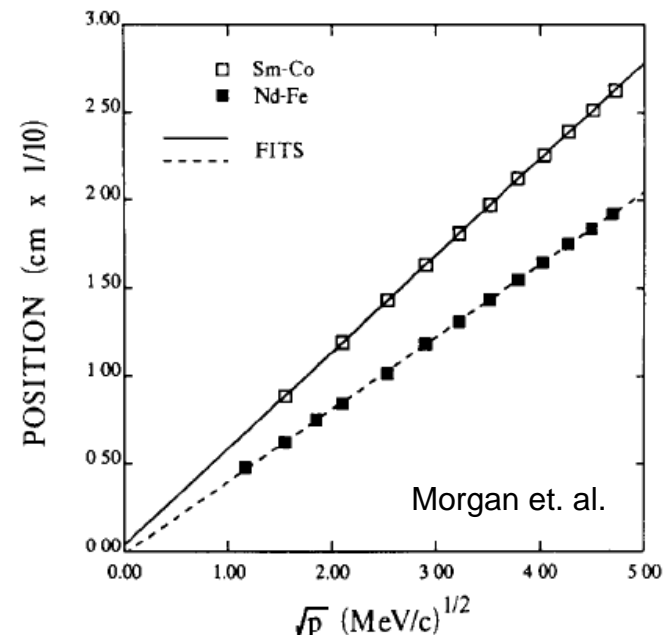
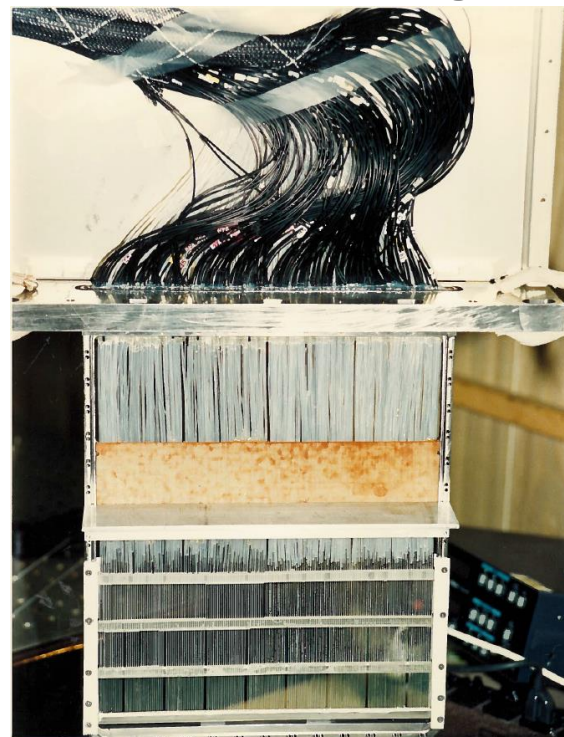
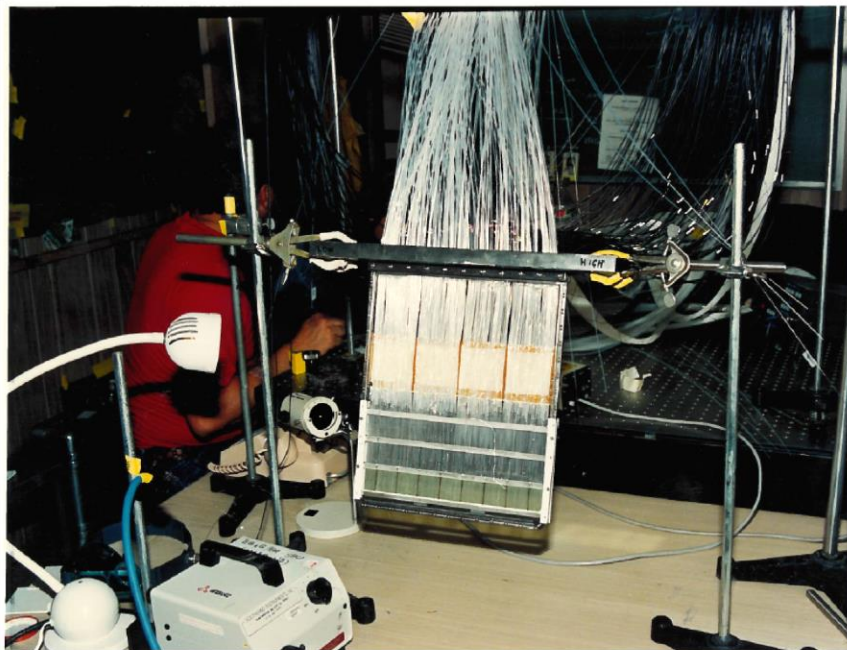


Fig. 13. Measured positions along the focal plane in the two spectrometers versus the square root of momentum. The error bars on the data are smaller than the symbol size. The solid curve is a fit to the data.

# Detector System

- Evaluating 3 internal options: scintillator + optical fibers, scintillating fibers, or measurement of Cerenkov radiation from normal fibers
- Goals: Bin size  $\leq 250$  keV and  $\sim 1$  ns time resolution
- Light detection from fibers: streak camera? PMT? Something else?



## Path forward

- Measure DAHRT spectrum early next year (?, H. Hermann P-24)
- Build, test, and calibrate time-resolved detector system
- Determine and test detector system shielding
- Measure spectra at RITS
- In parallel, design and fabricate lower field magnet for Cygnus
  - Field currently 632 G/cm and electron energy range 1-20 MeV; 100 G/cm would shrink the range to 0.?-3 MeV
- Modify detector system if necessary for low-energy spectrometer
- Measure Cygnus spectrum
- Possible spectrum measurements at other facilities

